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CALIBRATION OF INSTRUMENTATION FOR VIBRATION AND DAMPING TESTS.(U)

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6 CALIBRATION OF INSTRUMENTATION FOR VIBRATION AND DAMPING TESTS.

By

10 H. N. Phelps, Jr. Matthew F. Borg

USL Technical Memorandum No. 933-236-63

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INTRODUCTION

A High Frequency Vibration Laboratory, (reference (a)), has been established in Building 22 for conducting vibration and damping tests pertinent to the design and development of sonar domes. Electronic equipment necessary for the studies has been installed.

This memorandum discusses the calibration of the electronic equipment that will be used in conducting vibration and damping tests of plates, materials and dome structures.

9 Technical memo.

BACKGROUND

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Studies on the damping properties of materials have been made in the past at the Laboratory by Barger and Rogers, references (b) and (c). A compendium of information on surface damping applications, summarizing work at both the Laboratory and other institutions has been published, reference (d).

All of the previous tests were concerned with the effectiveness of the damping material in reducing the level of the radiated sound arising from flexural vibrations of plate structures, with particular emphasis given to submarine hull construction. Tests on materials that hinder the propagation of longitudinal (acoustic) vibrations have also been performed in evaluating baffle materials, reference (e).

However, additional experiments for sonar-dome applications have to be performed in order to find the effectiveness of presently known or future developed materials in reducing flexural vibrations in dome windows; transmitting longitudinal vibrations through dome windows; reducing flexural vibrations and reflecting or attenuating

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longitudinal vibrations in dome structures; and reflecting and attenuating longitudinal vibrations by baffles.

The High Frequency Laboratory in Building 22 will permit evaluating the flexural vibration damping characteristics of promising materials. Air tests of coated plates (or beams) are the first steps to be taken in testing each material. Calibration of electronic equipment, which is discussed in this memorandum, will be used for recording the damping properties of the various coated structures. Future tests will involve plate and curved panel tests in water in order to determine the flexural and longitudinal vibration characteristics of the coated structure or material.

ELECTRONIC EQUIPMENT

Figure 1 shows the block diagram of the electronic equipment that was used during the calibration tests. For future tests, the oscillator, attenuator and pulser will be replaced by suitable accelerometers attached to the item to be tested.

The components consist of: a Hewlett Packard low frequency oscillator, Model 202CR; a Hewlett Packard electronic counter, Model 5212A; a Daven attenuator, Type T-890 AR; an Endevco cathode follower, Model 2608; an Endevco power supply, Model 2622; a Bruel and Kjaer audio frequency spectrometer, Type 2109; a logarithmic amplifier; and a Tektronix storage oscilloscope, Type 564.

The purpose of the electronic counter is to ensure that the oscillator operates at the correct frequency. The decade attenuator is used to calibrate the oscilloscope. The audio frequency spectrometer is used as a $1/3$ octave band filter in the frequency range of 200 to 16,000 cps. The logarithmic amplifier is used to linearize an exponential function. The final signal is displayed on the storage oscilloscope.

CALIBRATION PROCEDURE

The electronic equipment was allowed to warm up for about one-half hour. The input voltage was on the order of 500 millivolts. The frequencies in the $1/3$ octave band center were varied from 200 cps to 16,000 cps. In each case, a continuous wave was put through the system, and the vertical scale of the oscilloscope was calibrated in decibels per centimeter using the decade attenuator. After the scope was calibrated, a pulse of pure tone, equivalent to the center frequency of the filter band, was sent through the system. The pulse and the

decay of the system were recorded on the storage oscilloscope. The slope of the function was then found directly in decibels per second; the slope is the decay rate of the electronic circuit. This same procedure was repeated for each of the third octave band center frequencies.

DETERMINATION OF DAMPING COEFFICIENTS

Reference (b) outlines the procedure for computing the decay rate of a damped single-degree-of-freedom system. In place of the logaten described in reference (b), a logarithmic amplifier and a decade attenuator were used to obtain the deflection calibration constant.

Figure 2 is a plot of the calibration decay rate (db/sec) versus $1/3$ octave filter band center frequencies. The excitation was a pure tone, equivalent to the center frequency of the filter band. The decay rate of an untreated steel plate, 20" x 20" x 3/8" taken from reference (f), is shown for comparison. The decay rate of a 30" x 30" x 3/8" untreated steel plate is similar.

Figure 3 is a plot of the percentage of critical camping, % c/c_c, which is determined from the relationship:

$$\eta_c/c_c = 1.84 \text{ D/f} \quad (1)$$

where: D = decay rate, db/sec (from figure 2)
 f = center frequency of filter band, cps
 c = the damping coefficient, lb.-sec./in.
 c_c = the critical damping coefficient, lb.-sec./in.

For comparison purposes, figure 3 also shows the percentage of critical damping for a bare untreated steel plate.

SUMMARY

Calibration tests have been performed on the electronic instrumentation that will be used in evaluating the damping properties of materials.

The plots that have been prepared show the decay rate and percent of critical damping versus the $1/3$ octave band center frequency.

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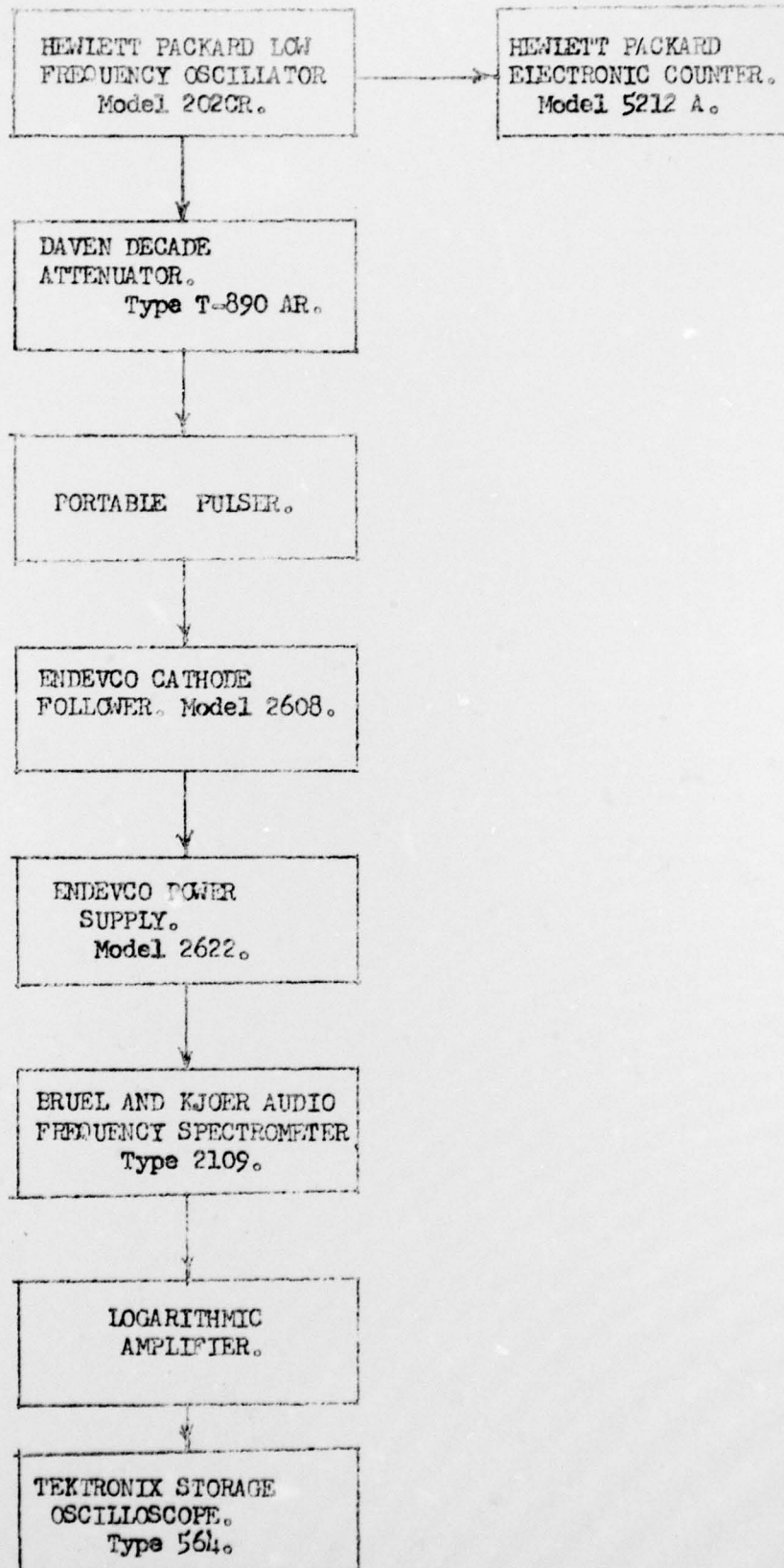
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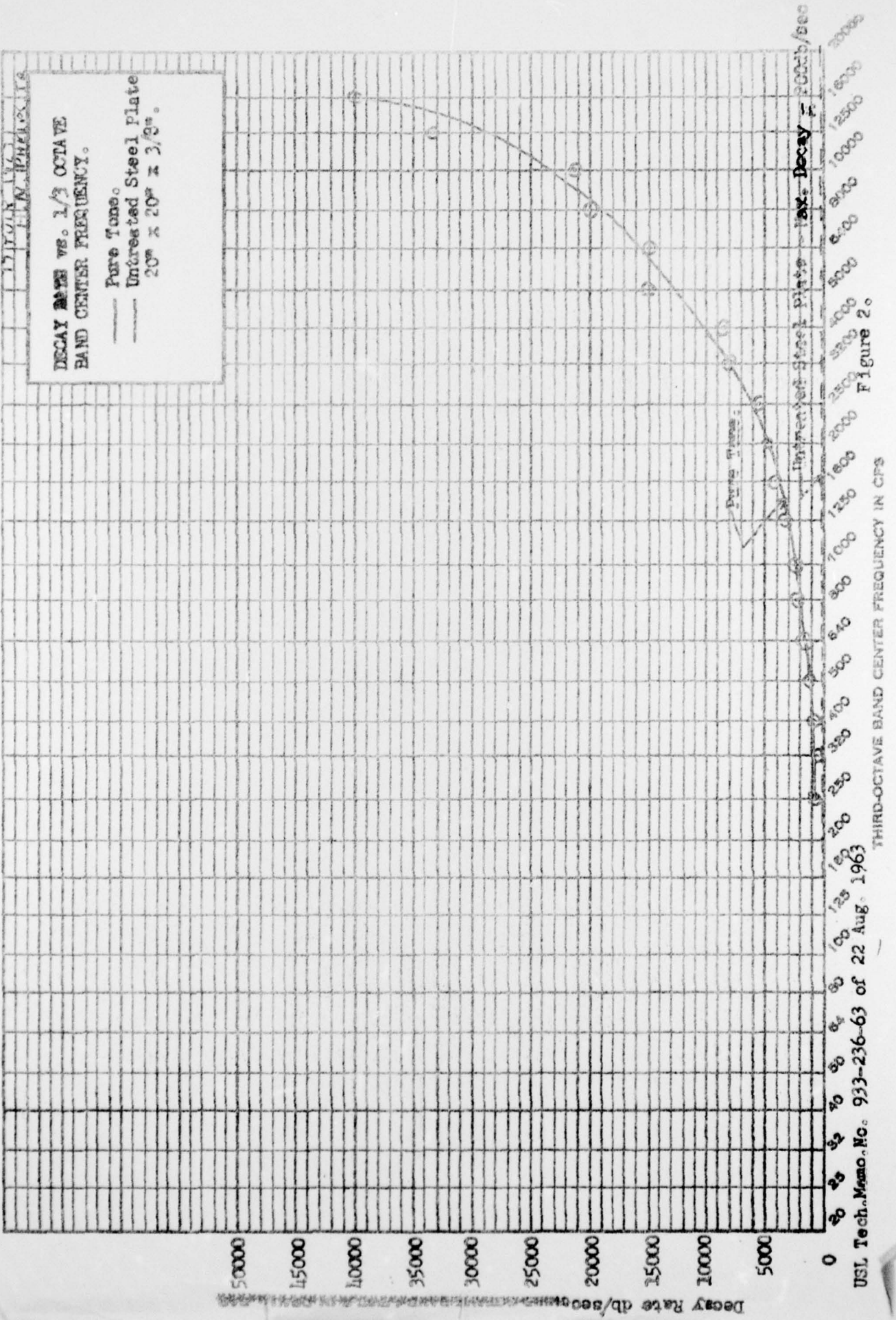
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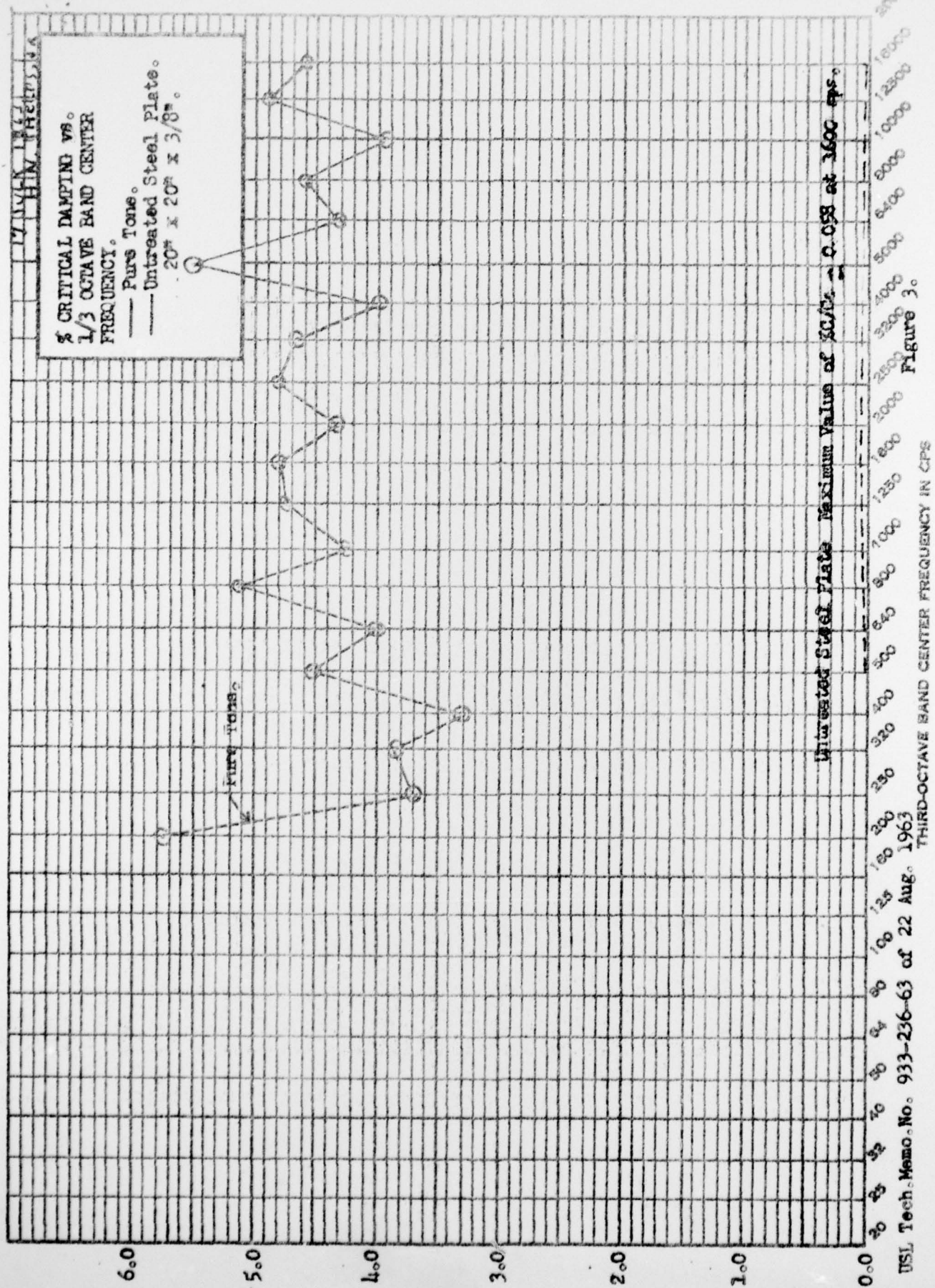
INSTRUMENTATION FOR VIBRATION AND DAMPING STUDIES.

Figure 1.

USL Tech. Memo. No. 932-236-63 of 22 Aug. 1963



USL Tech. Memo. No. 933-236-63 of 22 Aug. 1963
 Figure 2.



USL Tech. Memo.
No. 933-236-63

List of References

- (a) A. Donn Cobb and M. P. Borg, "Arrangement of Equipment and Modifications for High Frequency Laboratory - Building 22," USL Technical Memorandum No. 932-177-62, 3 August 1962.
- (b) LTJG J. E. Barger, USN, "An Experimental Determination of the Degree of Damping of Structures," USL Technical Memorandum No. 1210-94-59, 17 June 1959.
- (c) J. H. Rogers, "Decay Rate Measurements for Two Thicknesses Rubber-Tar Applied to 30" x 30" x 3/8" Steel Panels," USL Technical Memorandum No. 922-55-61, 3 March 1961.
- (d) R. F. DelSanto, Jr., "Compendium of Information on Surface Damping Applications," USL Technical Memorandum No. 1466-3-60, 23 Mar. 1960
- (e) T. G. Bell, "Baffle Transmission Loss Measurements in the USL 300-PSI Pressure Tank," USL Technical Memorandum No. 1230-058-55, 27 March 1955 (CONFIDENTIAL)
- (f) J. H. Rogers, "Decay Rate Measurements on Two 3/8" Steel Plates," USL Technical Memorandum No. 922-56-61, 6 March 1961.